US008782918B2

(12) **United States Patent**
Aoki et al.

(10) **Patent No.: US 8,782,918 B2**
(45) **Date of Patent: Jul. 22, 2014**

(54) **HEAT PROCESSING APPARATUS AND HEAT PROCESSING METHOD**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 660 days.

(21) Appl. No.: **13/155,013**

(22) Filed: **Jun. 7, 2011**

(65) **Prior Publication Data**

US 2011/0236845 A1 Sep. 29, 2011

Related U.S. Application Data

(62) Division of application No. 11/624,404, filed on Jan. 18, 2007, now Pat. No. 7,980,003.

(30) **Foreign Application Priority Data**

Jan. 25, 2006 (JP) 2006-015926

(51) **Int. Cl.**
F26B 3/20 (2006.01)
H01L 21/677 (2006.01)
F26B 21/00 (2006.01)
F26B 9/10 (2006.01)

(52) **U.S. Cl.**
CPC ***F26B 3/20*** (2013.01); *H01L 21/677* (2013.01); *F26B 21/001* (2013.01); *F26B 9/103* (2013.01)
USPC **34/78**; 134/10

(58) **Field of Classification Search**
CPC F26B 3/00; F26B 3/20; F26B 9/00; F26B 9/103; F26B 11/00; F26B 20/00; F26B 21/00; F26B 21/001; F26B 21/06; H01L 21/00; H01L 21/671; B08B 5/00
USPC 34/443, 485, 549; 134/105
See application file for complete search history.

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(57) **ABSTRACT**

A heat processing apparatus includes a heating plate configured to heat the substrate; a cover configured to surround a space above the heating plate; an exhaust gas flow forming mechanism configured to exhaust gas inside the cover to form exhaust gas flows within the space above the heating plate; a downflow forming mechanism configured to form downflows uniformly supplied onto an upper surface of the substrate placed on the heating plate; and a control mechanism configured to execute mode switching control between a mode arranged to heat the substrate while forming the downflows by the downflow forming mechanism and a mode arranged to heat the substrate while forming the exhaust gas flows by the exhaust gas flow forming mechanism.

16 Claims, 15 Drawing Sheets

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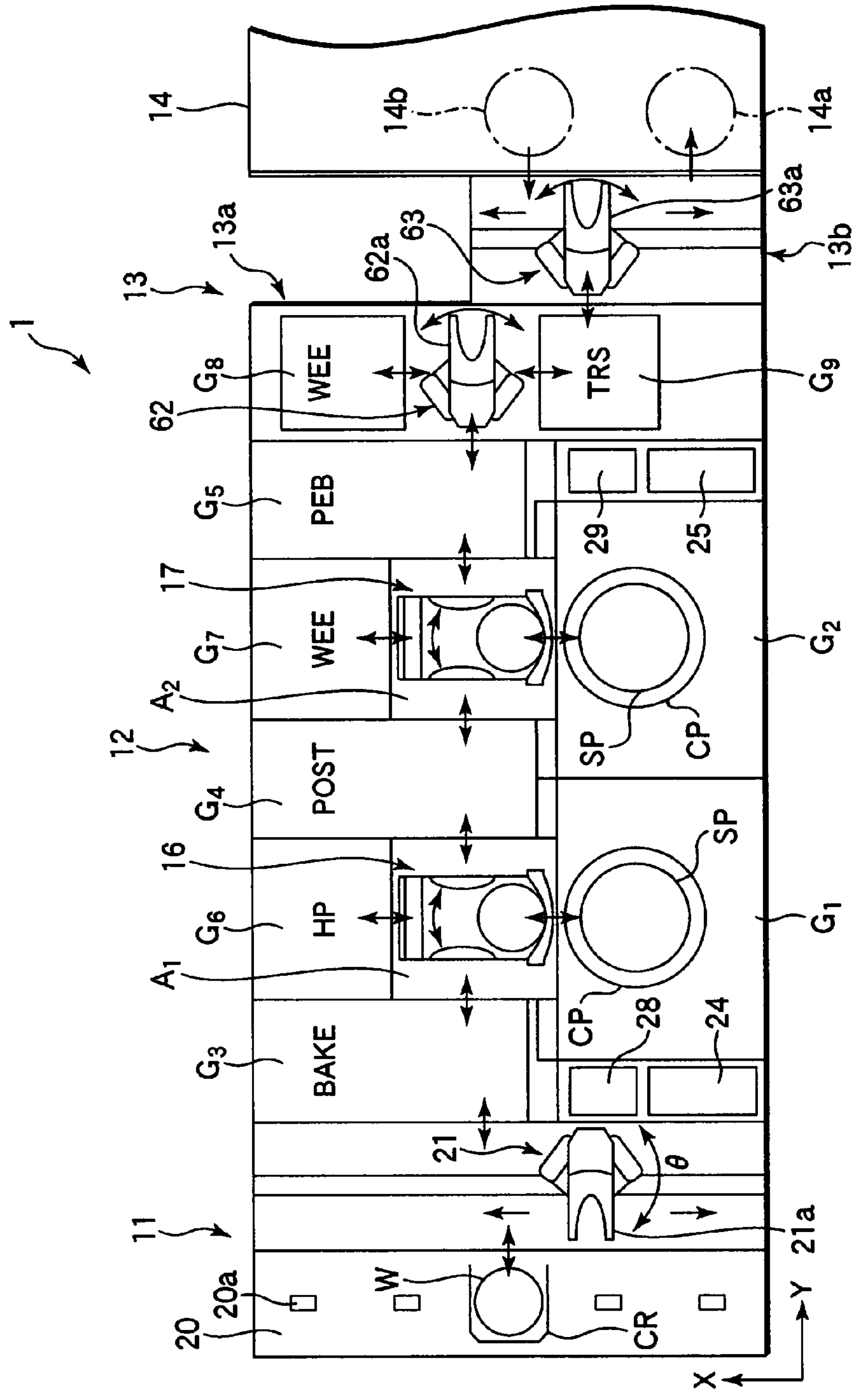


FIG.1

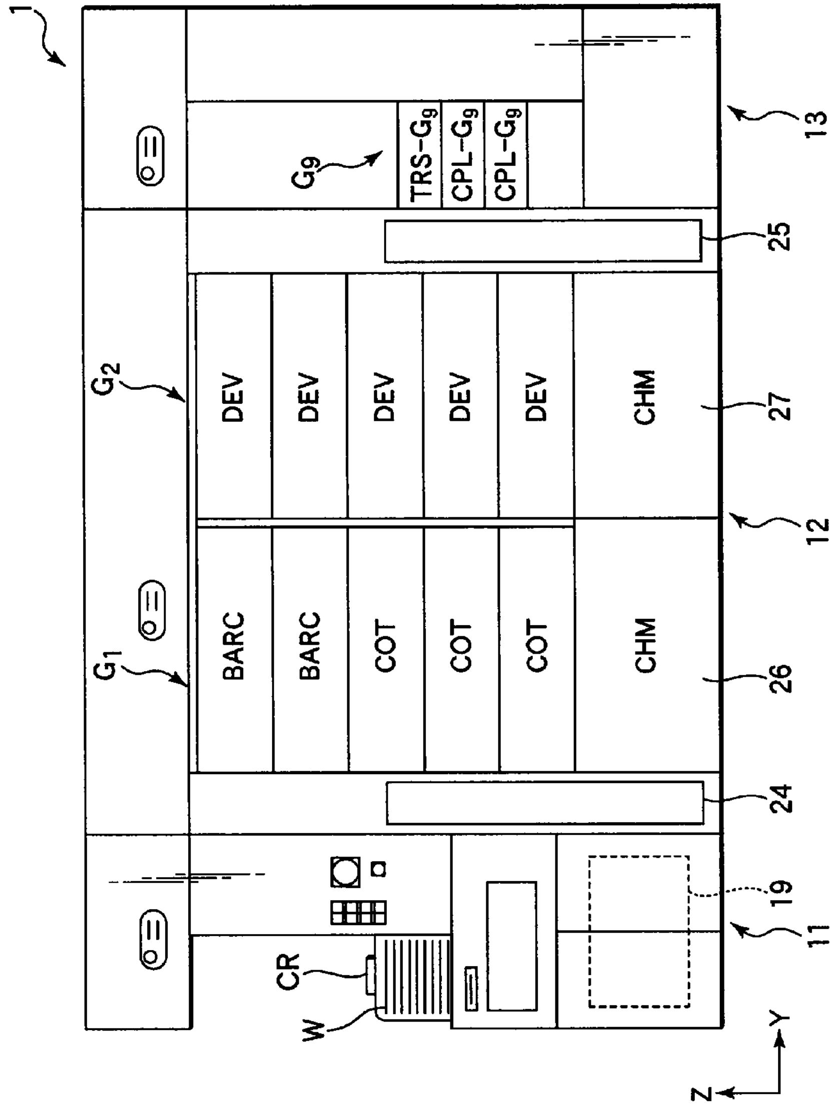


FIG.2

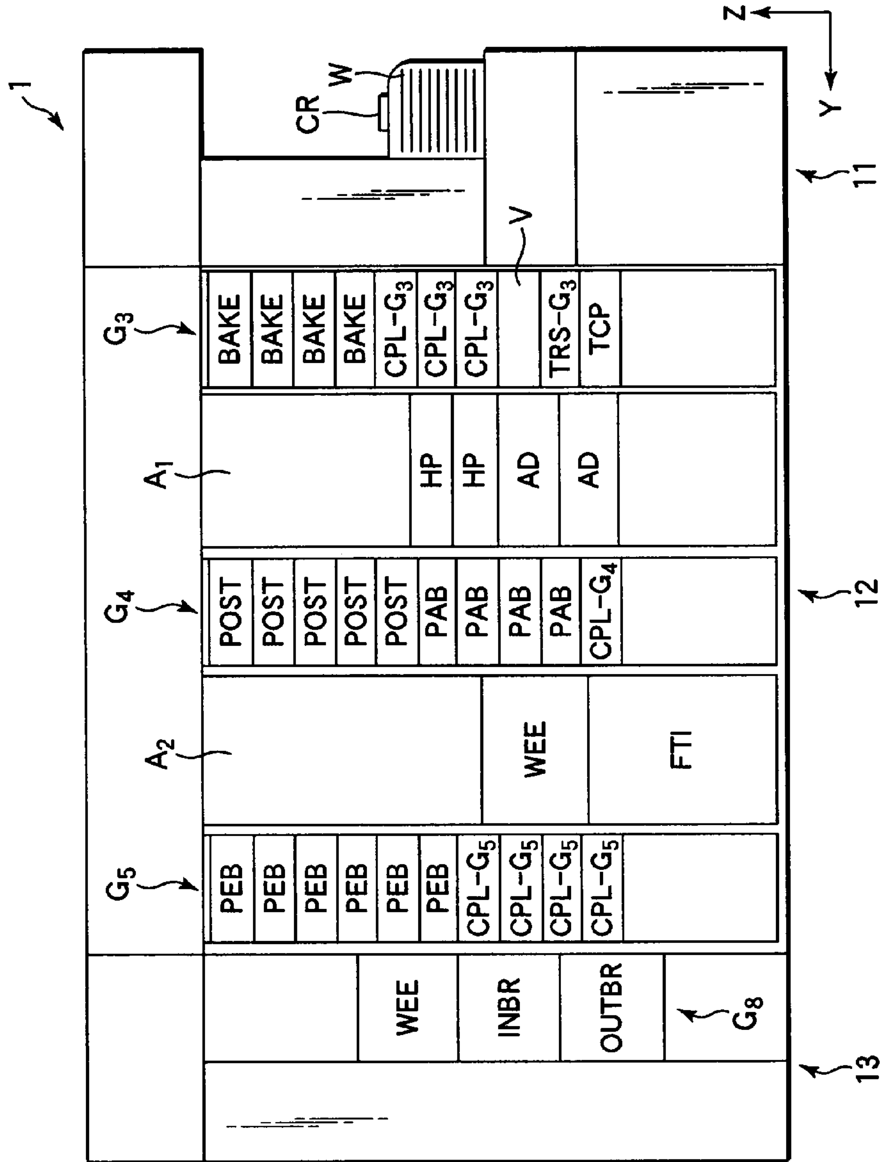


FIG.3

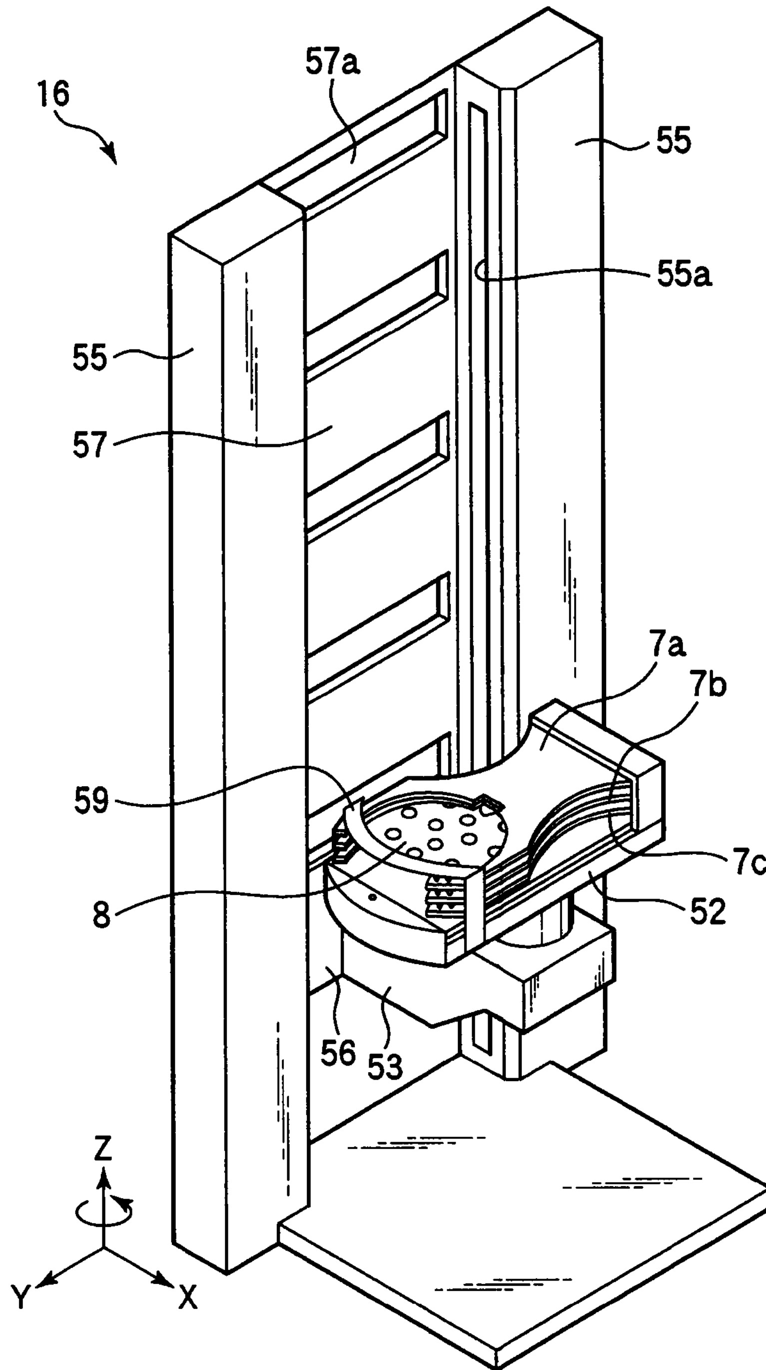


FIG.4

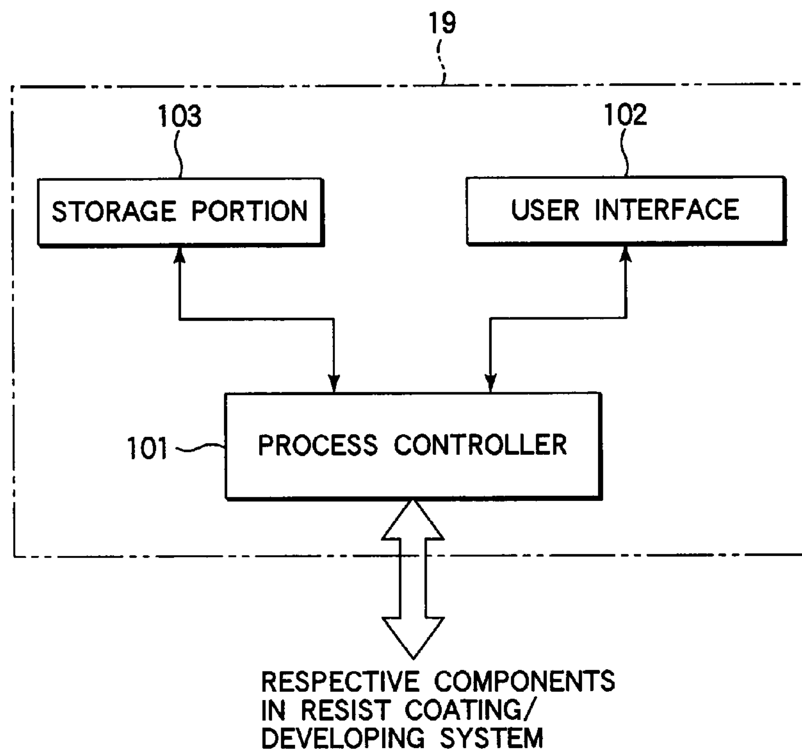


FIG.5

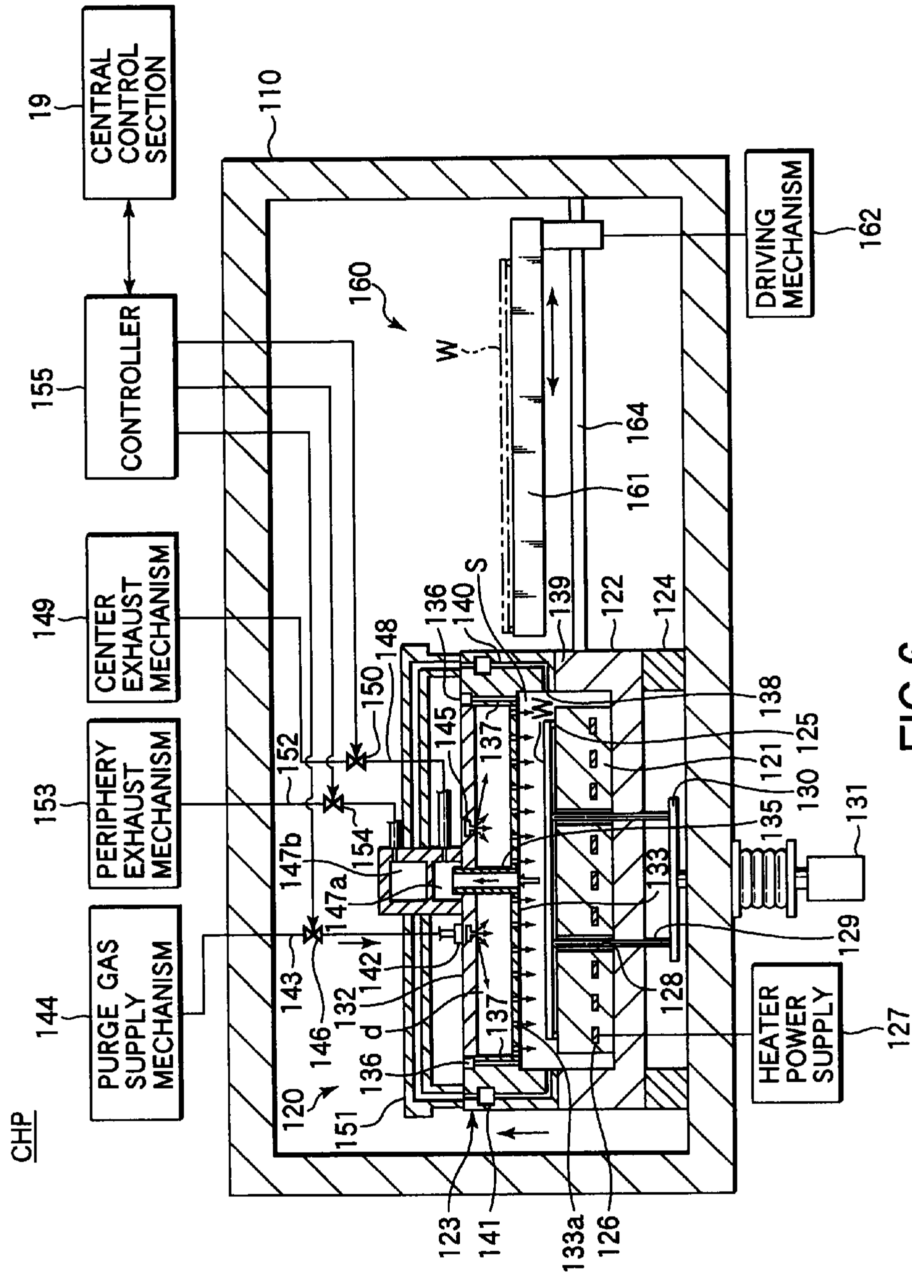


FIG.6

FIG.7

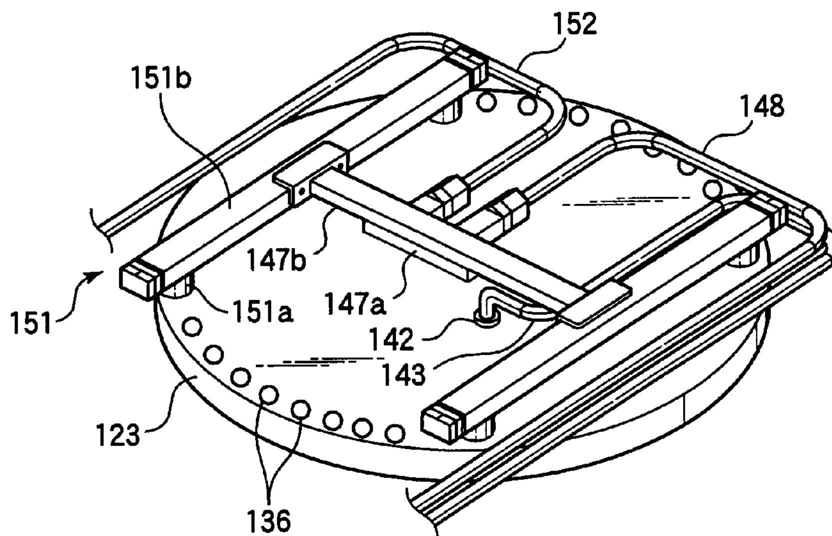


FIG.8

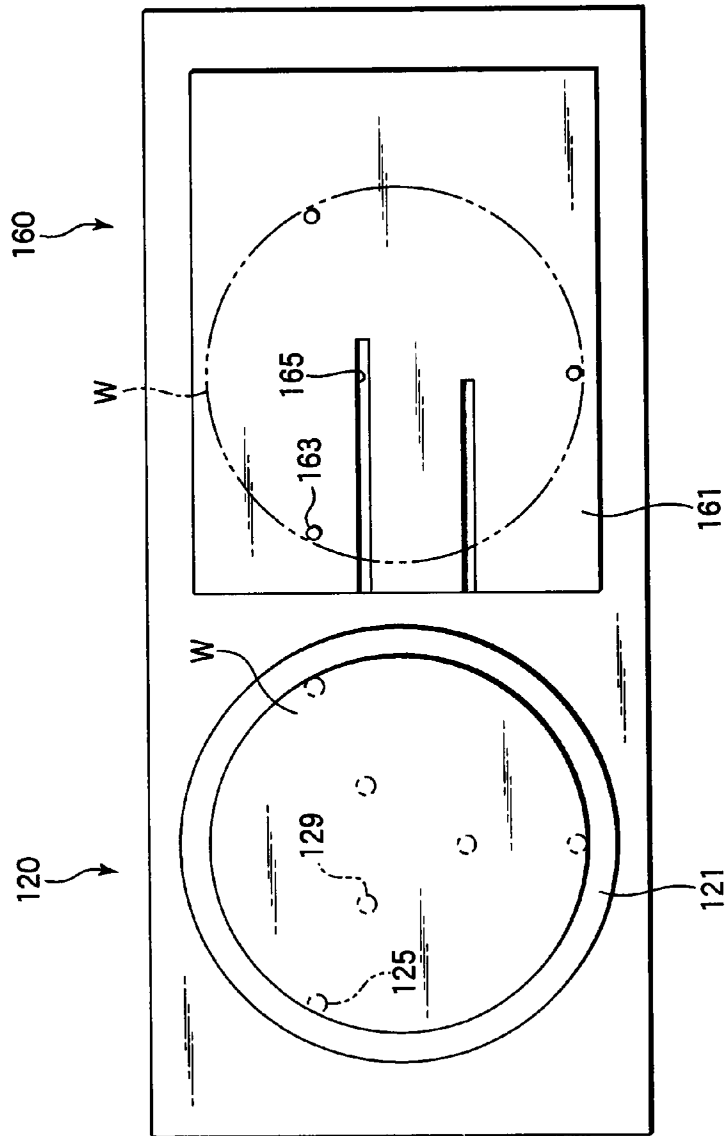


FIG.9

FIG.10A

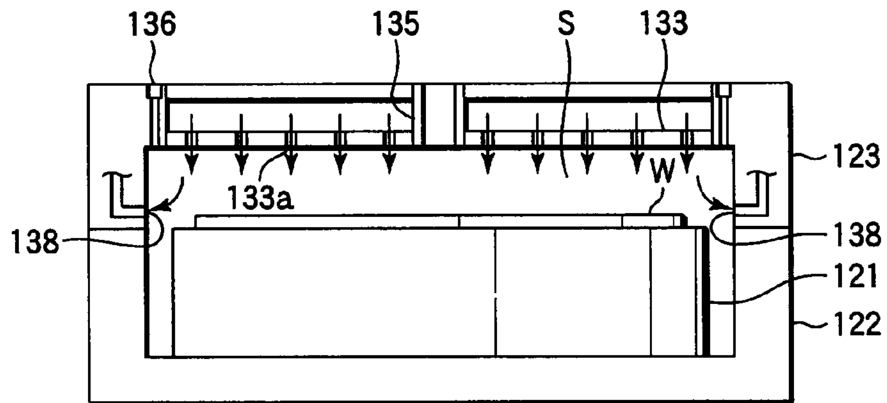
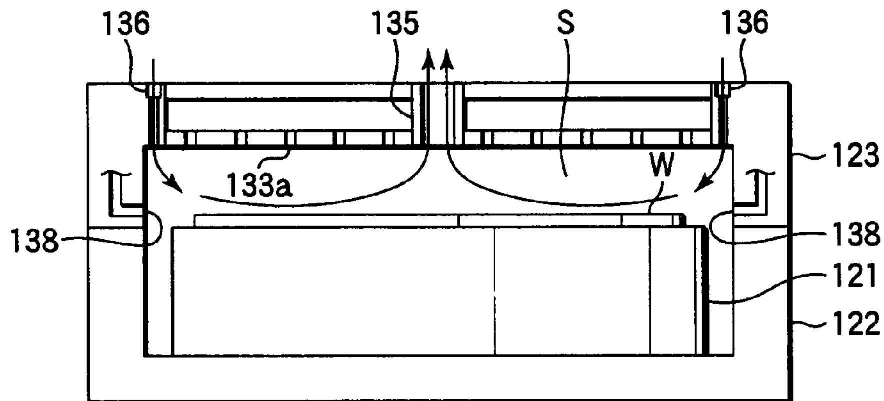


FIG.10B



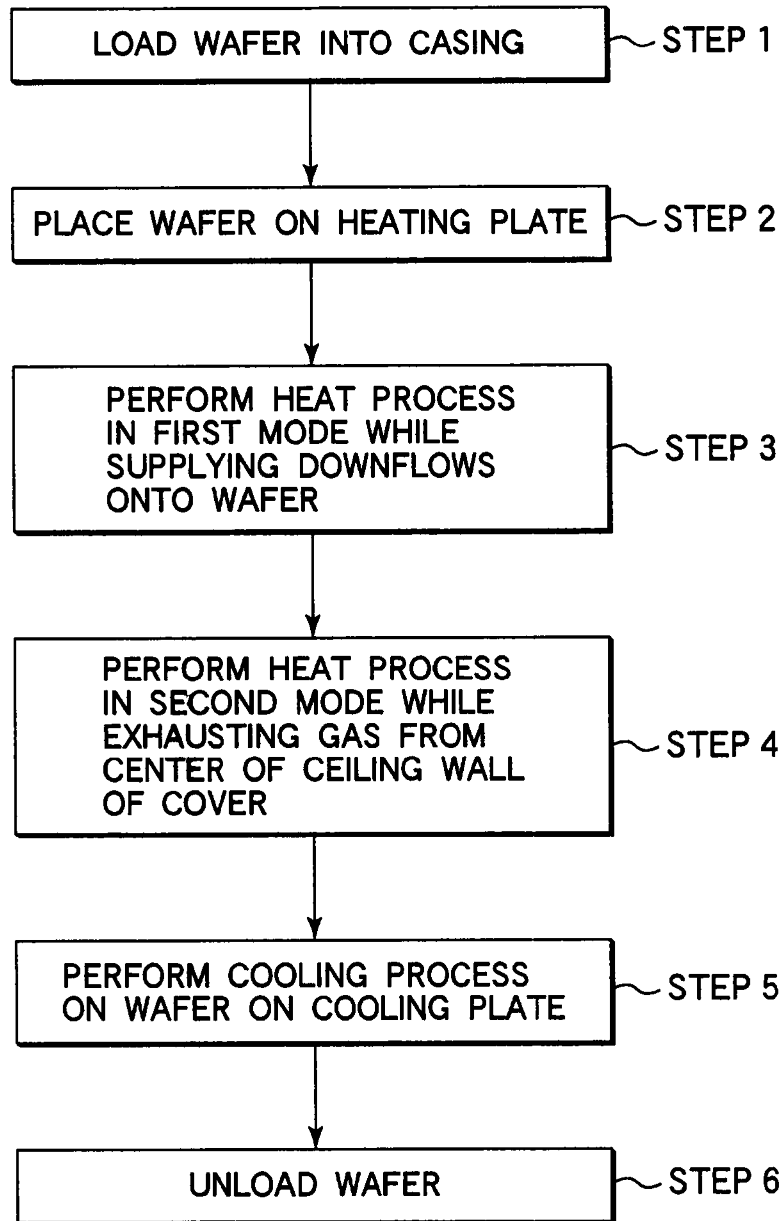


FIG.11

FIG.12A

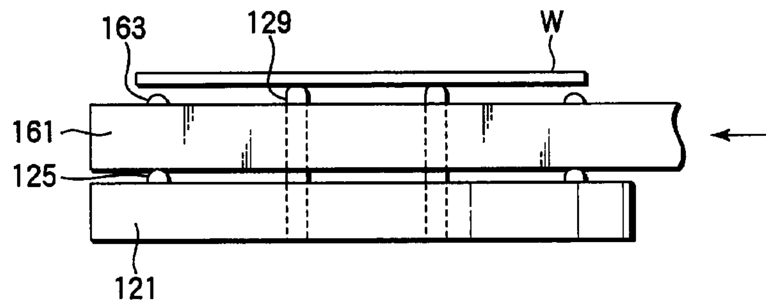


FIG.12B

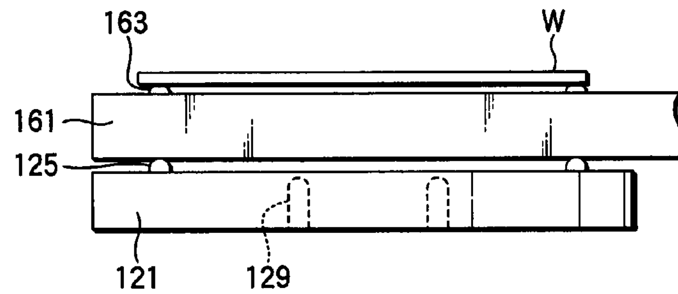
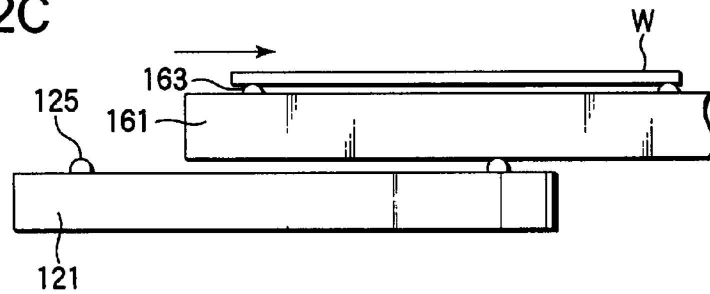


FIG.12C



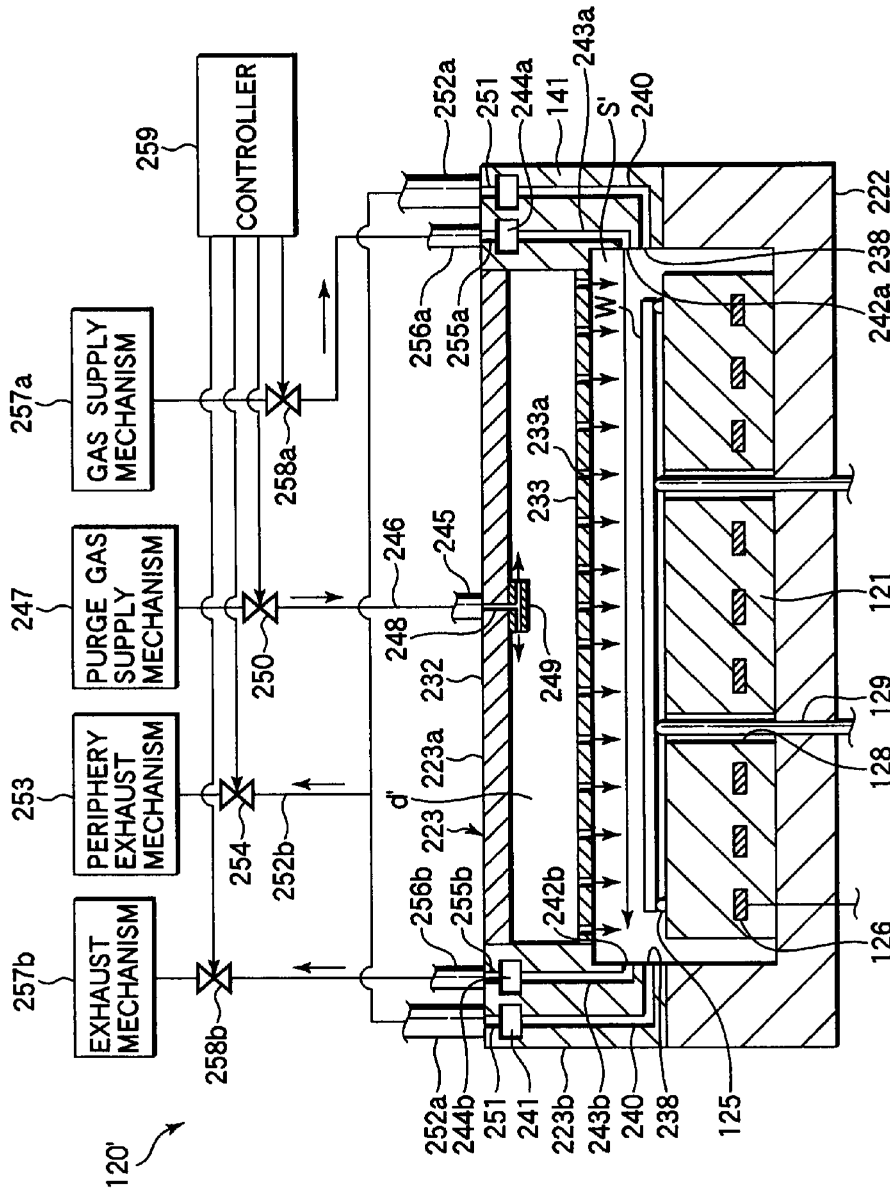


FIG.13

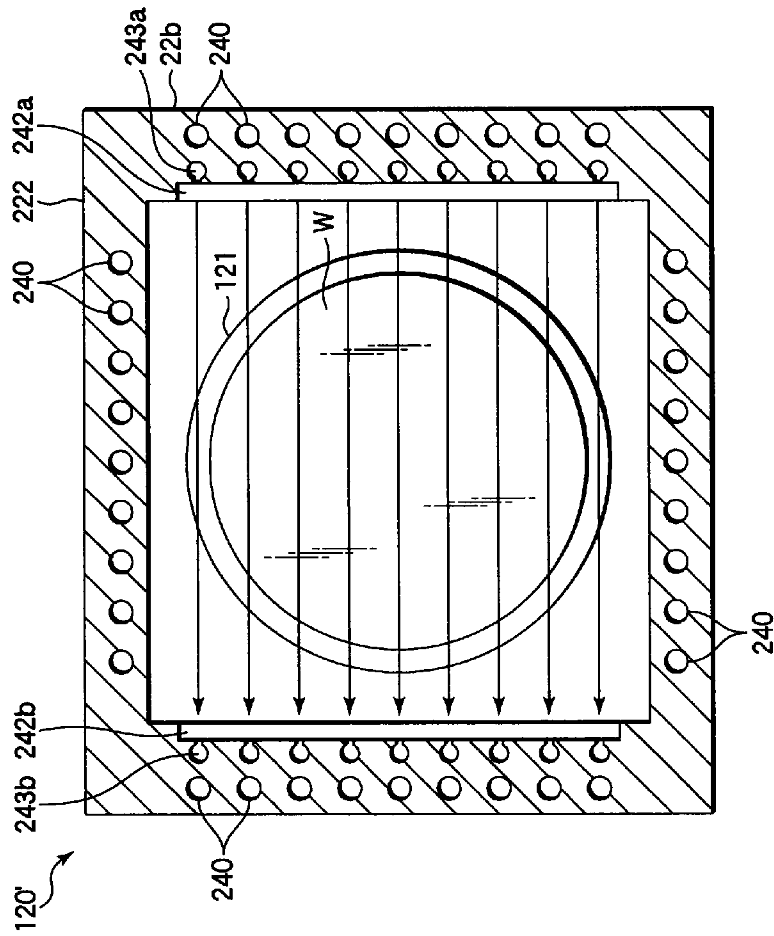


FIG.14

FIG.15A

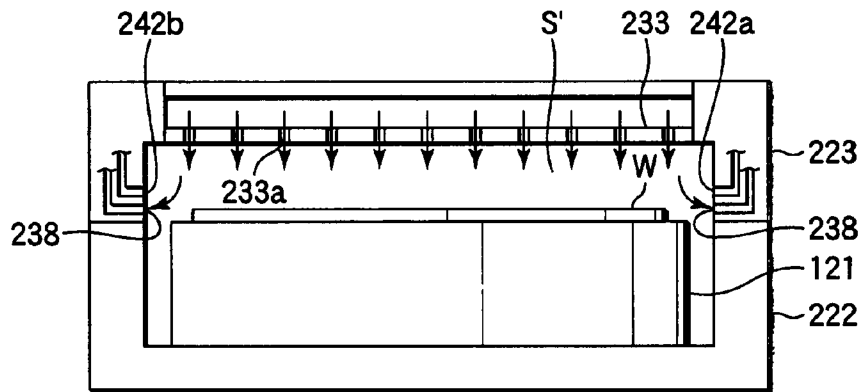
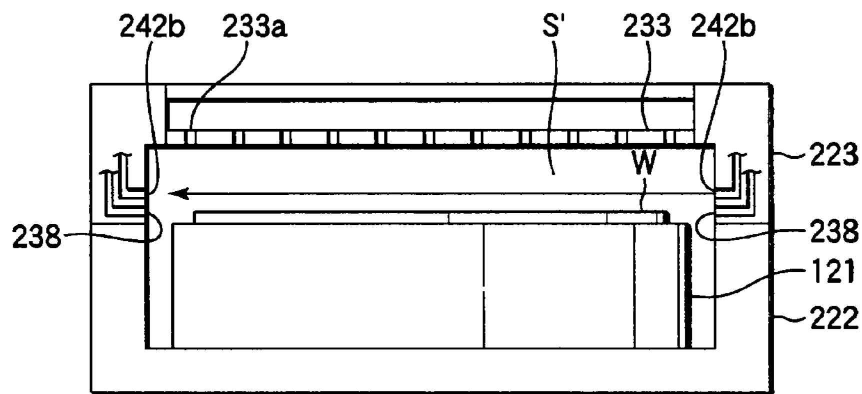


FIG.15B



HEAT PROCESSING APPARATUS AND HEAT PROCESSING METHOD

CROSS REFERENCE TO RELATED APPLICATION

The present divisional application claims the benefit of priority under 35 U.S.C. 120 to application Ser. No. 11/624,404, filed Jan. 18, 2007, and claims the benefit of priority under 35 U.S.C. 119 from Japanese Application No. 2006-015926, filed on Jan. 25, 2006. The entire contents of application Ser. No. 11/624,404 are hereby incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a heat processing apparatus and heat processing method for heating a substrate, which are used for manufacturing semiconductor devices while performing a coating/developing process on a substrate, such as a semiconductor wafer.

2. Description of the Related Art

In a photolithography step for semiconductor devices, a resist is applied onto a semiconductor wafer (which will be simply referred to as "wafer" hereinafter) to form a resist film. Then, the resist film is subjected to a light exposure process in accordance with a predetermined circuit pattern. Then, the light-exposed pattern thus formed is subjected to a developing process to form a circuit pattern on the resist film.

In a photolithography step of this type, various heat processes are performed, such as a heat process (pre-baking) performed subsequently to coating of a resist or a chemical solution for, e.g., a BARC, a heat process (post exposure baking) performed subsequently to light exposure, and a heat process (post baking) performed subsequently to development.

In general, these heat processes are performed by a heat processing apparatus (hot plate unit) provided with a heating plate (hot plate) heated by a heater. Conventionally, in a heat processing apparatus of this type, the following gas flow control is typically adopted to perform a heat process on a wafer as uniform as possible. Specifically, during the heat process, the heating plate is covered with a cover, in which gas flows are formed from around the heating plate toward the center, and gas is exhausted upward from the center of the cover.

In recent years, circuit patters of semiconductor devices show rapid progress in decreasing the line width, in decreasing the size, and in increasing the degree of integration, which requires the process uniformity of heat processes to be further improved. However, by use of the gas flow control described above, it has become difficult to attain desired process uniformity, particularly uniformity concerning gas flows relative to a wafer, which is necessary to uniformize critical dimensions (CD). Accordingly, it is required to provide a technique for performing a heat process with higher uniformity. As a technique for realizing a heat process with higher uniformity, Jpn. Pat. Appln. KOKAI Publication No. 2003-318091 discloses a technique for performing a heat process while supplying gas flows from above uniformly onto the entire surface of a substrate. According to this technique, since the gas flows uniformly strike the entire surface of the substrate, such as a wafer, it is possible to improve the process uniformity, particularly uniformity in the film thickness of a coating film.

However, devices for the next generation require very minute patterns with a CD value of 50 nm or less, in which even slight dust may cause a defect. Accordingly, it is necessary to swiftly remove sublimed substances and so forth generated by a heat process. In this respect, the technique disclosed in Jpn. Pat. Appln. KOKAI Publication No. 2003-318091 mentioned above cannot sufficiently remove sublimed substances and so forth, and thus it may deteriorate the yield of products. Particularly, such deterioration in the yield due to sublimed substances is easily caused in a coating film for argon fluoride (ArF) having a short wavelength. This coating film is used for further improving the resolving power of light exposure in accordance with a CD for the next generation.

Further, depending on coating films, heat processes of this kind include processes that should give weight to CD uniformity and processes that should give weight to an improvement in the product yield by removing substances, such as sublimed substances, that generate dust. However, the technique disclosed in Jpn. Pat. Appln. KOKAI Publication No. 2003-318091 mentioned above cannot address the latter type. Accordingly, there is a great demand for a heat processing technique that can address these two types.

BRIEF SUMMARY OF THE INVENTION

An object of the present invention is to provide a heat processing apparatus and heat processing method that can realize both of high uniformity and high product yield.

An alternative object of the present invention is to provide a heat processing apparatus that can perform both of a process that gives weight to high uniformity and a process that gives weight to high product yield.

A further alternative object of the present invention is to provide a computer readable storage medium that stores a control program for executing the heat processing method described above.

According to a first aspect of the present invention, there is provided a heat processing apparatus for performing a heat process on a substrate, the apparatus comprising: a heating plate configured to heat the substrate; a cover configured to surround a space above the heating plate; a first gas flow forming mechanism configured to form gas flows mainly arranged to realize a uniform heat process, within the space above the heating plate; and a second gas flow forming mechanism configured to form gas flows mainly arranged to exhaust and remove gas and/or sublimed substances generated from the substrate, within the space above the heating plate, wherein the first gas flow forming mechanism and the second gas flow forming mechanism are selectively switchable therebetween.

According to a second aspect of the present invention, there is provided a heat processing apparatus for performing a heat process on a substrate, the apparatus comprising: a heating plate configured to heat the substrate; a cover configured to surround a space above the heating plate; a first gas flow forming mechanism configured to form gas flows mainly arranged to realize a uniform heat process, within the space above the heating plate; a second gas flow forming mechanism configured to form gas flows mainly arranged to exhaust and remove gas and/or sublimed substances generated from the substrate, within the space above the heating plate; and a control mechanism configured to execute mode switching control between a mode arranged to heat the substrate while forming the gas flows by the first gas flow forming mechanism and a mode arranged to heat the substrate while forming the gas flows by the second gas flow forming mechanism.

[There are Deleted Portions.]

In the first or second aspect of the present invention, the first gas flow forming mechanism may be configured to form downflows uniformly supplied onto an upper surface of the substrate placed on the heating plate. The second gas flow forming mechanism may be configured to exhaust the space above the heating plate to form gas flows along the substrate.

[There are Deleted Portions.]

According to a third aspect of the present invention, there is provided a heat processing apparatus for performing a heat process on a substrate, the apparatus comprising: a heating plate configured to heat the substrate; a cover configured to surround a space above the heating plate; an exhaust gas flow forming mechanism configured to exhaust gas inside the cover to form exhaust gas flows within the space above the heating plate; and a downflow forming mechanism configured to form downflows uniformly supplied onto an upper surface of the substrate placed on the heating plate, wherein modes are switchable between a mode arranged to heat the substrate while forming the downflows by the downflow forming mechanism and a mode arranged to heat the substrate while forming the exhaust gas flows by the exhaust gas flow forming mechanism.

[There are Deleted Portions.]

In the third aspect of the present invention, the downflow forming mechanism may comprise a gas supply mechanism configured to supply a gas as a shower onto the upper surface of the substrate from a ceiling wall of the cover, and a periphery exhaust mechanism configured to exhaust gas outwardly in radial directions from the substrate. The exhaust gas flow forming mechanism may comprise an exhaust portion located at the center of a ceiling wall of the cover and a gas feed portion configured to supply a gas from around the substrate into the space above the heating plate, such that a gas is supplied from the gas feed portion and is exhausted from the exhaust portion to form exhaust gas flows from a periphery of the substrate toward a center thereof, within the space above the heating plate. Alternatively, the exhaust gas flow forming mechanism may comprise a gas feed portion and an exhaust portion respectively located on opposite sides of the space above the heating plate, such that a gas is supplied from the gas feed portion and is exhausted from the exhaust portion to form exhaust gas flows from one side of the substrate toward an opposite side thereof, within the space above the heating plate.

According to a fifth aspect of the present invention, there is provided a heat processing method for performing a heat process by use of a heat processing apparatus, which comprises a heating plate configured to heat the substrate, a cover configured to surround a space above the heating plate, a first gas flow forming mechanism configured to form gas flows mainly arranged to realize a uniform heat process, within the space above the heating plate, and a second gas flow forming mechanism configured to form gas flows mainly arranged to exhaust and remove gas and/or sublimed substances generated from the substrate, within the space above the heating plate,

the method comprising: heating the substrate while forming the gas flows by the first gas flow forming mechanism; and heating the substrate while forming the gas flows by the second gas flow forming mechanism.

In the fifth aspect of the present invention, the method preferably comprises first heating the substrate while forming the gas flows by the first gas flow forming mechanism, and then heating the substrate while forming the gas flows by the second gas flow forming mechanism. Further, said heating the substrate while forming the gas flows by the first gas flow forming mechanism may be performed while forming downflows uniformly supplied onto an upper surface of the substrate placed on the heating plate. Further, said heating the substrate while forming the gas flows by the second gas flow forming mechanism may be performed while exhausting gas from the space above the heating plate to form gas flows along the substrate.

[There are Deleted Portions.]

According to a sixth aspect of the present invention, there is provided a heat processing method for performing a heat process by use of a heat processing apparatus, which comprises a heating plate configured to heat the substrate, a cover configured to surround a space above the heating plate, an exhaust gas flow forming mechanism configured to exhaust an atmosphere inside the cover from above or sidewise to form exhaust gas flows within the space above the heating plate, and a downflow forming mechanism configured to form downflows uniformly supplied onto an upper surface of the substrate placed on the heating plate,

the method comprising: heating the substrate while forming the downflows by the downflow forming mechanism; and heating the substrate while forming the exhaust gas flows by the exhaust gas flow forming mechanism within the space above the heating plate.

[There are Deleted Portions.]

In the sixth aspect of the present invention, said heating the substrate while forming the downflows by the downflow forming mechanism may comprise forming the downflows by supplying a gas as a shower onto the upper surface of the substrate from a ceiling wall of the cover while exhausting gas outwardly in radial directions from the substrate. Further, said heating the substrate while forming the exhaust gas flows by the exhaust gas flow forming mechanism within the space above the heating plate may be performed while forming the exhaust gas flows from a periphery of the substrate toward a center thereof, within the space above the heating plate. Alternatively, said heating the substrate while forming the exhaust gas flows by the exhaust gas flow forming mechanism within the space above the heating plate may be performed while forming the exhaust gas flows from one side of the substrate toward an opposite side thereof, within the space above the heating plate.

[There are Deleted Portions.]

According to a seventh aspect of the present invention, there is provided a computer readable storage medium that stores a control program for execution on a computer used for a heat processing apparatus, which comprises a heating plate configured to heat the substrate, a cover configured to surround a space above the heating plate, a first gas flow forming mechanism configured to form gas flows mainly arranged to realize a uniform heat process, within the space above the heating plate, and a second gas flow forming mechanism configured to form gas flows mainly arranged to exhaust and remove gas and/or sublimed substances generated from the substrate, within the space above the heating plate, wherein the control program, when executed, causes the computer to control the heat processing apparatus to conduct a heat processing method comprising: heating the substrate while forming the gas flows by the first gas flow forming mechanism; and heating the substrate while forming the gas flows by the second gas flow forming mechanism.

According to an eighth aspect of the present invention, there is provided a computer readable storage medium that stores a control program for execution on a computer used for a heat processing apparatus, which comprises a heating plate configured to heat the substrate, a cover configured to surround a space above the heating plate, an exhaust gas flow

forming mechanism configured to exhaust an atmosphere inside the cover from above or sidewise to form exhaust gas flows within the space above the heating plate, and a downflow forming mechanism configured to form downflows uniformly supplied onto an upper surface of the substrate placed on the heating plate, wherein the control program, when executed, causes the computer to control the heat processing apparatus to conduct a heat processing method comprising: heating the substrate while forming the downflows by the downflow forming mechanism; and heating the substrate while forming the exhaust gas flows by the exhaust gas flow forming mechanism within the space above the heating plate.

According to the present invention, there is provided a heat processing apparatus comprising: a first gas flow forming mechanism configured to form gas flows mainly arranged to realize a uniform heat process, within the space above the heating plate; and a second gas flow forming mechanism configured to form gas flows mainly arranged to exhaust and remove gas and/or sublimed substances generated from the substrate, within the space above the heating plate, wherein the first gas flow forming mechanism and the second gas flow forming mechanism are selectively switchable therebetween. More specifically, there is provided a heat processing apparatus comprising: an exhaust gas flow forming mechanism configured to exhaust gas inside the cover to form exhaust gas flows within the space above the heating plate; and a downflow forming mechanism configured to form downflows uniformly supplied onto an upper surface of the substrate placed on the heating plate, wherein modes are switchable between a mode arranged to heat the substrate while forming the downflows by the downflow forming mechanism and a mode arranged to heat the substrate while forming the exhaust gas flows by the exhaust gas flow forming mechanism. Consequently, it is possible to perform both of a process that gives weight to high uniformity and a process that gives weight to high product yield, in accordance with a substrate.

Further, since the apparatus is controlled to switch these modes therebetween, it is possible to serially perform a process that gives weight to high uniformity and a process that gives weight to high product yield, thereby realizing both of high uniformity and high product yield.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. **1** is a plan view showing the entire structure of a resist coating/developing system for semiconductor wafers, which is provided with a heat processing unit according to an embodiment of the present invention;

FIG. **2** is a front view of the resist coating/developing system shown in FIG. **1**;

FIG. **3** is a back view of the resist coating/developing system shown in FIG. **1**;

FIG. **4** is a perspective view schematically showing the structure of a main wafer transfer unit used in the resist coating/developing system shown in FIG. **1**;

FIG. **5** is a block diagram showing a control system used in the resist coating/developing system shown in FIG. **1**;

FIG. **6** is a sectional view showing a heat processing unit according to an embodiment of the present invention;

FIG. **7** is an enlarged sectional view showing a heating section used in the heat processing unit according to an embodiment of the present invention;

FIG. **8** is a perspective view showing the cover of the heating section used in the heat processing unit according to an embodiment of the present invention;

FIG. **9** is a plan view schematically showing the interior of the heat processing unit according to an embodiment of the present invention;

FIGS. **10**A and **10**B are views schematically showing the heat processing unit according to an embodiment of the present invention, set in a first mode and a second mode, respectively;

FIG. **11** is a flowchart showing a heat processing method performed in the heat processing unit according to an embodiment of the present invention;

FIGS. **12**A to **12**C are views schematically showing the heat processing unit according to an embodiment of the present invention, to explain procedures for transferring a wafer to a cooling plate after a heat process;

FIG. **13** is an enlarged sectional view showing a heating section used in a heat processing unit according to an alternative embodiment of the present invention;

FIG. **14** is a sectional plan view schematically showing the heating section used in the heat processing unit according to an alternative embodiment of the present invention; and

FIGS. **15**A and **15**B are views schematically showing the heat processing unit according to an alternative embodiment of the present invention, set in a first mode and a second mode, respectively.

DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the present invention will now be described with reference to the accompanying drawings. FIG. **1** is a plan view schematically showing a resist coating/developing system for semiconductor wafers, which is provided with a heat processing unit according to an embodiment of the present invention. FIGS. **2** and **3** are a front view and a back view, respectively, of the resist coating/developing system shown in FIG. **1**.

This resist coating/developing system **1** includes a transfer station used as a cassette station **11**, a process station **12** comprising a plurality of processing units, and an interface station **13** located adjacent to the process station **12** and configured to transfer wafers W between a light exposure apparatus **14** and the process station **12**.

The cassette station **11** is used such that wafer cassettes (CR) are transferred thereto from other systems, wherein each of these wafer cassettes (CR) stores a plurality of wafers W to be processed in the resist coating/developing system **1**. The cassette station **11** is also arranged such that wafer cassettes (CR) are transferred therefrom to other systems, wherein each of these wafer cassettes (CR) stores wafers W processed in the resist coating/developing system **1**. Further, the cassette station **11** is used to transfer wafers W between the wafer cassettes (CR) and process station **12**.

As shown in FIG. **1**, the cassette station **11** includes a cassette table **20** having a plurality of (five in FIG. **1**) positioning projections **20*a*** formed thereon in a row in an X-direction. A wafer cassette (CR) is placed at each of the projections **20*a*** such that its wafer transfer port faces the process station **12**.

The cassette station **11** is provided with a wafer transfer mechanism **21** located between the cassette table **20** and process station **12**. This wafer transfer mechanism **21** includes a wafer transfer pick **21*a***, which is movable in a cassette array direction (X-direction) and in a wafer array direction (Z-direction) of the wafers W stored in each wafer cassette (CR), and is further rotatable in a Θ-direction show in FIG. **1**. With the arrangement described above, the wafer transfer pick **21*a*** can access any one of the wafer cassettes

(CR), and also can access a transition unit (TRS-G**3**) located in a third processing unit group G**3** of the process station **12** described later.

On the front side of the system, the process station **12** includes a first processing unit group G**1** and a second processing unit group G**2** arrayed in this order from the cassette station **11**. Further, on the rear side of the system, the process station **12** includes a third processing unit group G**3**, a fourth processing unit group G**4**, and a fifth processing unit group G**5** arrayed in this order from the cassette station **11**. A first main transfer section A**1** is interposed between the third processing unit group G**3** and fourth processing unit group G**4**. A second main transfer section A**2** is interposed between the fourth processing unit group G**4** and fifth processing unit group G**5**. A sixth processing unit group G**6** is located on the rear side of the first main transfer section A**1**. A seventh processing unit group G**7** is located on the rear side of the second main transfer section A**2**.

As shown in FIGS. **1** and **2**, the first processing unit group G**1** includes five processing units of the spinner type stacked one on the other, which are used as liquid supply units each for performing a predetermined process on a wafer W placed on a spin chuck SP inside a cup (CP). For example, the five processing units are formed of three resist coating units (COT) and two bottom coating units (BARC) for forming an anti-reflective coating that prevents reflection of light during light exposure. The second processing unit group G**2** includes five processing units of the spinner type, such as development units (DEV), stacked one on the other.

The third processing unit group G**3** includes ten units or the like stacked one on the other, as shown in FIG. **3**, which are formed of a temperature adjusting unit (TCP), a transition unit (TRS-G**3**), a spare space V, three high-precision temperature adjusting units (CPL-G**3**), and four high-temperature heat processing units (BAKE) in this order from below. The transition unit (TRS-G**3**) is used as a portion for transferring a wafer W between the cassette station **11** and first main transfer section A**1**. The spare space V is used for attaching a desired processing unit of the oven type, such as a processing unit of the oven type for performing a predetermined process on a wafer W placed on a worktable. Each of the high-precision temperature adjusting units (CPL-G**3**) is used for performing a heat process on a wafer W at a temperature controlled with high precision. Each of the high-temperature heat processing units (BAKE) is used for performing a predetermined heat process on a wafer W.

The fourth processing unit group G**4** includes ten units or the like stacked one on the other, as shown in FIG. **3**, which are formed of a high-precision temperature adjusting unit (CPL-G**4**), four pre-baking units (PAB), and five post baking units (POST) in this order from below. Each of the pre-baking units (PAB) is used for performing a heat process on a wafer W after resist coating. Each of the post baking units (POST) is used for performing a heat process on a wafer W after a developing process.

The fifth processing unit group G**5** includes ten units or the like stacked one on the other, as shown in FIG. **3**, which are formed of four high-precision temperature adjusting units (CPL-G**5**) and six post exposure baking units (PEB) in this order from below. Each of the post exposure baking units (PEB) is used for performing a heat process on a wafer W after light exposure and before development.

The high-temperature heat processing units (BAKE), pre-baking units (PAB), post baking units (POST), and post exposure baking units (PEB) located in the third to fifth processing unit groups G**3** to G**5** have the same structure, as described later, which forms a heat processing unit according to this embodiment. In the third to fifth processing unit groups G**3** to G**5**, the number and position of units stacked one on the other are not limited to those shown in the drawings, and they can be arbitrarily preset.

The sixth processing unit group G**6** includes four units or the like stacked one on the other, which are formed of two adhesion units (AD) and two heating units (HP) for heating a wafer W in this order from below. Each of the adhesion units (AD) may have a mechanism for adjusting the temperature of a wafer W. The seventh processing unit group G**7** includes two units or the like stacked one on the other, which are formed of a film thickness measuring unit (FTI) and a periphery light exposure unit (WEE) in this order from below. The film thickness measuring unit (FTI) is used for measuring the thickness of a resist film. The periphery light exposure unit (WEE) is used for performing light exposure selectively only on the edge portion of a wafer W. A plurality of periphery light exposure units (WEE) may be used and stacked one the other. Further, on the rear side of the second main transfer section A**2**, a heat processing unit, such as a heating unit (HP), may be disposed, as in the rear side of the first main transfer section A**1**.

The first main transfer section A**1** is provided with a first main wafer transfer unit **16**, which can selectively access the units located in the first processing unit group G**1**, third processing unit group G**3**, fourth processing unit group G**4**, and sixth processing unit group G**6**. The second main transfer section A**2** is provided with a second main wafer transfer unit **17**, which can selectively access the units located in the second processing unit group G**2**, fourth processing unit group G**4**, fifth processing unit group G**5**, and seventh processing unit group G**7**.

As shown in FIG. **4**, the first main wafer transfer unit **16** includes three arms **7***a*, **7***b*, and **7***c* each for holding a wafer W. These arms **7***a* to **7***c* are movable back and forth along a base plate **52**. The base plate **52** is rotatably supported by a support portion **53** and can be rotated by a motor built in the support portion **53**. The support portion **53** is movable up and down along support struts **55** extending in the vertical direction. The support struts **55** are respectively provided with sleeves **55***a* extending in a vertical direction, while a flange portion **56** laterally projected from the support portion **53** slidably engages with sleeves **55***a*. The support portion **53** can be moved up and down by an elevating mechanism (not shown) through the flange portion **56**. With this arrangement, the arms **7***a* to **7***c* of the first main wafer transfer unit **16** are movable in the X-direction, Y-direction, and Z-direction, and is rotatable in the X-Y plane. Consequently, as described above, the first main wafer transfer unit **16** can selectively access the units located in the first processing unit group G**1**, third processing unit group G**3**, fourth processing unit group G**4**, and sixth processing unit group G**6**.

A shield plate **8** is attached between the arm **7***a* and arm **7***b* to block off radiation heat from these arms. Further, a light emitting element (not shown) of a sensor member **59** is located above the distal end of the uppermost arm **7***a*, while a light receiving element (not shown) is attached at the distal end of the base plate **52**. The light emitting element and light receiving element constitute an optical sensor to confirm the presence/absence and protruding of a wafer W on each of the arms **7***a* to **7***c*. FIG. **4** also shows a wall portion **57** as a part of the housing of the first main transfer section A**1** on the first processing unit group G**1** side. The wall portion **57** has window portions **57***a* formed therein, through which a wafer W is transferred to and from the respectively units of the first

processing unit group G**1**. The second main wafer transfer unit **17** has the same structure as that of the first main wafer transfer unit **16**.

A liquid temperature adjusting pump **24** and a duct **28** are located between the first processing unit group G**1** and cassette station **11**. A liquid temperature adjusting pump **25** and a duct **29** are located between the second processing unit group G**2** and interface station **13**. The liquid temperature adjusting pumps **24** and **25** are used for supplying predetermined process liquids to the first processing unit group G**1** and second processing unit group G**2**, respectively. The ducts **28** and **29** are used for supplying clean air into the processing unit groups G**1** to G**5** from an air conditioner (not shown) located outside the resist coating/developing system **1**.

The first to seventh processing unit groups G**1** to G**7** are detachable for a maintenance operation. The rear side panel of the process station **12** is also detachable or openable. Further, chemical units (CHM) **26** and **27** are respectively located below the first processing unit group G**1** and second processing unit group G**2** and are used for supplying predetermined process liquids to the first processing unit group G**1** and second processing unit group G**2**.

The interface station **13** comprises a first interface station **13***a* on the process station **12** side, and a second interface station **13***b* on the light exposure apparatus **14** side. The first interface station **13***a* is provided with a first wafer transfer device **62** that faces an opening of the fifth processing unit group G**5**. The second interface station **13***b* is provided with a second wafer transfer device **63** movable in the X-direction.

An eighth processing unit group G**8** is located on the rear side of the first wafer transfer device **62**. The eighth processing unit group G**8** includes units or the like stacked one on the other, as shown in FIG. **3**, which are formed of an outgoing buffer cassette (OUTBR), an incoming buffer cassette (INBR), and a periphery light exposure unit (WEE) in this order from below. The outgoing buffer cassette (OUTBR) is used for temporarily placing wafers W transferred from the light exposure apparatus **14**. The incoming buffer cassette (INBR) is used for temporarily placing wafers W to be transferred into the light exposure apparatus **14**. Each of the incoming buffer cassette (INBR) and outgoing buffer cassette (OUTBR) is configured to accommodate a plurality of, e.g., 25, wafers W. Further, a ninth processing unit group G**9** is located on the front side of the first wafer transfer device **62**. The ninth processing unit group G**9** includes units or the like stacked one on the other, as shown in FIG. **2**, which are formed of two high-precision temperature adjusting units (CPL-G**9**) and a transition unit (TRS-G**9**) in this order from below.

The first wafer transfer device **62** includes a wafer transfer fork **62***a*, which is movable in the Z-direction, rotatable in the θ-direction, and further movable back and forth in the X-Y plane. This fork **62***a* can selectively access the units located in the fifth processing unit group G**5**, eighth processing unit group G**8**, and ninth processing unit group G**9**, so that wafers W can be transferred among these units.

Similarly, the second wafer transfer device **63** includes a wafer transfer fork **63***a*, which is movable in the X-direction and Z-direction, rotatable in the θ-direction, and further movable back and forth in the X-Y plane. This fork **63***a* can selectively access the units located in the ninth processing unit group G**9**, and an incoming stage **14***a* and an outgoing stage **14***b* of the light exposure apparatus **14**, so that wafers W can be transferred among these portions.

As shown in FIG. **2**, a central control section **19** is located below the cassette station **11** and is used for controlling this resist coating/developing system **1**, as a whole. As shown in FIG. **5**, this central control section **19** includes a process controller **101** comprising a CPU for controlling the respective components included in the resist coating/developing system **1**, such as the processing units and transfer mechanisms. The process controller **101** is connected to the user interface **102**, which includes, e.g., a keyboard and a display, wherein the keyboard is used for a process operator to input commands for operating the respective components in the resist coating/developing system **1**, and the display is used for showing visualized images of the operational status of the respective components in the resist coating/developing system **1**. Further, the process controller **101** is connected to the storage portion **103**, which stores recipes with control programs and process condition data recorded therein, for realizing various processes performed in the resist coating/developing system **1** under the control of the process controller **101**.

A required recipe is retrieved from the storage portion **103** and executed by the process controller **101** in accordance with an instruction or the like input through the user interface **102**. Consequently, each of various predetermined processes is performed in the resist coating/developing system **1** under the control of the process controller **101**. Recipes may be stored in a computer readable storage medium, such as a CD-ROM, hard disk, flexible disk, or nonvolatile memory. Further, recipes may be utilized on-line, while it is transmitted from a suitable apparatus through, e.g., a dedicated line, as needed. Each of the respective components is provided with its own subordinate control section, which control the operation of the corresponding component in accordance with instructions transmitted from the process controller **101**.

In the resist coating/developing system **1** arranged as described above, unprocessed wafers W are taken out one by one from a wafer cassette (CR) by the wafer transfer mechanism **21**. A wafer W thus taken out is transferred by the wafer transfer mechanism **21** into the transition unit (TRS-G**3**) located in the processing unit group G**3** of the process station **12**. Then, the wafer W receives a temperature adjusting treatment in the temperature adjusting unit (TCP). Then, the wafer W is sequentially subjected to formation of an anti-reflective coating performed by one of the bottom coating units (BARC) of the first processing unit group G**1**, a heat process performed by one of the heating units (HP), and a baking process performed by one of the high-temperature heat processing units (BAKE). Before the formation of an anti-reflective coating performed by one of the bottom coating units (BARC), the wafer W may be subjected to an adhesion process performed by one of the adhesion units (AD). Then, the wafer W receives a temperature adjusting treatment in the high-precision temperature adjusting unit (CPL-G**4**). Then, the wafer W is transferred into one of the resist coating unit (COT) located in the first processing unit group G**1**, in which the wafer W is subjected to a process for applying a resist liquid. Thereafter, the wafer W is sequentially subjected to a pre-baking process performed by one of the pre-baking units (PAB) located in the fourth processing unit group G**4**, and a periphery light exposure process performed by one of the periphery light exposure units (WEE). Then, the wafer W receives a temperature adjusting treatment in the high-precision temperature adjusting unit (CPL-G**4**) or the like. Thereafter, the wafer W is transferred by the second wafer transfer device **63** into the light exposure apparatus **14**. After the wafer W is subjected to a light exposure process performed by the light exposure apparatus **14**, the wafer W is transferred by the second wafer transfer device **63** into the transition unit (TRS-G**9**). Then, the wafer W is transferred by the first wafer transfer device **62** into one of the post exposure baking units

(PEB) located in the fifth processing unit group G5, in which the wafer W is subjected to a post exposure baking process. Further, the wafer W is transferred into one of the development units (DEV) located in the second processing unit group G2, in which the wafer W is subjected to a developing process. Then, the wafer W is subjected to a post baking process performed by the post baking unit (POST). Then, the wafer W receives a temperature adjusting treatment in one of the high-precision temperature adjusting units (CPL-G3). Then, the wafer W is transferred by the transition unit (TRS-G3) to a predetermined position in a wafer cassette (CR) placed on the cassette station **11**.

Next, a detailed explanation will be given of the heat processing unit according to an embodiment of the present invention. As described above, the high-temperature heat processing units (BAKE), pre-baking units (PAB), post baking units (POST), and post exposure baking units (PEB) have the same structure, which forms a heat processing unit according to this embodiment, i.e., a heat processing unit (CHP) provided with a cooling plate. FIG. **6** is a sectional view showing the heat processing unit according to this embodiment. FIG. **7** is an enlarged sectional view showing a heating section used in the heat processing unit. FIG. **8** is a perspective view showing the cover of the heating section used in the heat processing unit. FIG. **9** is a plan view schematically showing the interior of the heat processing unit.

This heat processing unit (CHP) includes a casing **110**, in which a heating section **120** is located on one side, and a cooling section **160** is located on the other side.

The heating section **120** includes a heating plate **121** like a circular plate for heating a wafer W. The heating plate **121** is supported within the inner space of a support member **122** having a compressed circular cylindrical shape opened upward. The upper side of the support member **122** is covered with a cover **123** having a compressed circular cylindrical shape opened downward. The cover **123** can be moved up and down by an elevating mechanism (not shown). When the cover **123** is set at the upper position, the wafer W can be loaded and unloaded to and from the heating plate **121**. When the cover **123** is set at the lower position, the lower end of the cover **123** comes into close contact with the upper end of the support member **122** to form a heat processing space S. The support member **122** is fixed on a spacer **124** placed on the bottom of the casing **110**.

The heating plate **121** is made of, e.g., aluminum, and is provided with proximity pins **125** on the surface. The wafer W is placed on the proximity pins **125** to be adjacent to the heating plate **121**. The heating plate **121** has an electric heater **126** built therein with a predetermined pattern. Electricity is applied from a heater power supply **127** to this electric heater **126** to set the heating plate **121** at a predetermined temperature. The heating temperature is controlled by means of feedback control using a thermo couple (not shown) located near the surface of the heating plate **121**.

The heating plate **121** has three through holes **128** formed therein at the central portion (only two of them are shown in FIG. **6**). Lifter pins **129** are respectively inserted in these through holes **128** and are movable up and down to move the wafer W up and down. The lifter pins **129** are attached to a support plate **130** and are moved up and down along with the support plate **130** by a cylinder mechanism **131** located below the casing **110**.

As shown in the enlarged view of FIG. **7**, the cover **123** is formed of a ceiling wall **123***a* and a sidewall **123***b*. The ceiling wall **123***a* includes an upper plate **132** and a lower plate **133**, which define a gas diffusion space d therebetween. Further, the lower plate **133** of the ceiling wall **123***a* has a number of gas delivery holes **133***a* uniformly distributed. An exhaust pipe **135** is formed to penetrate the center of the ceiling wall **123***a* in the vertical direction. The sidewall **123***b* of the cover **123** has a plurality of air intake ports **136** opened on the upper surface and arrayed in an annular direction. A plurality of air feed passages **137** are formed in the sidewall **123***b* to connect the air intake ports **136** to the heat processing space S. In place of the air intake ports **136**, a gas feed mechanism for supplying another gas, such as N_2 gas, may be used.

The sidewall **123***b* of the cover **123** further has a plurality of gas exhaust ports **138** opened on the inner surface and arrayed along a lower side of the inner surface. A plurality of vertical exhaust passages **140** are formed in the sidewall **123***b* such that they extend horizontally from the gas exhaust ports **138** and then extend vertically upward. Further, a loop exhaust passage **141** is formed in an upper side of the sidewall **123***b*, and is connected to the vertical exhaust passages **140**.

The ceiling wall **123***a* of the cover **123** has a purge gas feed port **142** opened on the upper surface, which is connected to a purge gas supply mechanism **144** through a purge gas line **143**. The purge gas feed port **142** is connected to a loop flow passage **145** formed in the upper plate **132** through a flow passage (not shown). A plurality of gas delivery ports **145***a* are formed below the loop flow passage **145** to deliver the purge gas as a spray. With this arrangement, a purge gas is supplied from the purge gas supply mechanism **144** through the purge gas feed port **142**, flow passage (not shown), and loop flow passage **145**, and is then delivered from the delivery ports **145***a* as a spray into the gas diffusion space d. The purge gas thus supplied into the gas diffusion space d is then delivered from the gas delivery holes **133***a* of the lower plate **133** into the processing space S as a shower. The purge gas line **143** is provided with a valve **146** for turning on/off the purge gas and adjusting the flow rate thereof. As the purge gas, air or an inactive gas, such as N_2 gas or Ar gas, is preferably used.

At the center of the upper surface of the cover **123**, a first exhaust member **147***a* and a second exhaust member **147***b* are stacked one on the other in the vertical direction. The exhaust pipe **135** is inserted into the first exhaust member **147***a* on the lower side. The first exhaust member **147***a* is connected to a center exhaust mechanism **149** through an exhaust line **148**. The exhaust line **148** is provided with a valve **150** for turning on/off exhaust gas and adjusting the flow rate thereof. The inner atmosphere of the heat processing space S can be exhausted by the center exhaust mechanism **149** through the exhaust passage **35**, first exhaust member **147***a*, and exhaust line **148**.

A periphery exhaust member **151** is disposed on the upper surface of the cover **123**. As shown in FIG. **8**, the periphery exhaust member **151** includes vertical portions **151***a* located at four positions on the periphery of the upper surface of the cover **123**, and two horizontal portions **151***b* each connecting two of the four vertical portions **151***a*. The vertical portions **151***a* are connected to the loop exhaust passage **141** of the sidewall **123***b* through gas flow passages **141***a*. The central portions of the two horizontal portions **151***b* are connected to each other by the second exhaust member **147***b*. The central portion of the sidewall of the second exhaust member **147***b* is connected to a periphery exhaust mechanism **153** through an exhaust line **152**. The exhaust line **152** is provided with a valve **154** for turning on/off exhaust gas and adjusting the flow rate thereof. The interior of the heat processing space S can be exhausted by the periphery exhaust mechanism **153** from the exhaust ports **138** through the exhaust passages **139** and **140** and loop exhaust passage **141** and further through the periphery exhaust member **151**, second exhaust member **147***b*, and exhaust line **152**.

A controller **155** is used for turning on/off and adjusting the valves **146**, **150**, and **154**. The controller **155** controls the valves **146**, **150**, and **154** in accordance with instructions transmitted from the process controller **101** of the central control section **19** to switch modes between a first mode shown in FIG. **10**A and a second mode shown in FIG. **10**B. In the first mode, periphery exhaust is set in operation through the exhaust ports **138** while the purge gas is delivered from the gas delivery holes **133***a*, so that a heat process is performed while downflows are uniformly supplied onto the upper surface of the wafer W. In the second mode, air is drawn from the air intake ports **136** while gas is exhausted through the exhaust pipe **135** at the center of the ceiling wall **123***a* of the cover **123**, so that a heat process is performed, while gas flows (exhaust gas flows) are formed along the wafer W from the periphery of the wafer W toward the center, within the heat processing space S. In other words, the purge gas supply mechanism **144**, periphery exhaust mechanism **153**, gas delivery holes **133***a*, exhaust ports **138**, and lines connecting these portions constitute a first gas flow forming mechanism for forming gas flows used in the first mode. On the other hand, the center exhaust mechanism **149**, exhaust pipe **135**, air intake ports **136**, air feed passages **137**, and so forth constitute a second gas flow forming mechanism for forming gas flows used in the second mode.

The cooling section **160** includes a cooling plate **161** and a driving mechanism **162** for moving the cooling plate **161** in a horizontal direction. The cooling plate **161** is provided with proximity pins **163** thereon, so that the wafer W is placed on the proximity pins **163** to be adjacent to the cooling plate **161** during a cooling process. The driving mechanism **162** comprises a suitable mechanism, such as a belt mechanism or ball screw mechanism, to move the cooling plate **161** along a guide **164**. When the wafer W is transferred to and from the heating plate **121**, the cooling plate **161** is moved to the heating section **120** side. When a cooling or heating process is performed, the cooling plate **161** is set at a reference position shown in FIG. **6**. In order to prevent the cooling plate **161** thus moved from interfering with the lifter pins **129**, the cooling plate **161** has grooves **165** extending in a transfer direction of the cooling plate **161**, as shown in FIG. **9**.

The cooling plate **161** can be cooled by a cooling mechanism (not shown), and the cooling temperature is controlled by means of feedback control using a thermo couple (not shown) located near the surface of the cooling plate **161**.

Next, an explanation will be given of a heat processing operation performed in the heat processing unit arranged as described above, with reference to the flowchart shown in FIG. **11**. This explanation will be given of a heat process performed on a wafer W with a coating liquid applied thereon.

At first, a wafer W is transferred into the casing **110** (Step **1**), for example, after a predetermined coating liquid is applied thereto, or after a light exposure process is performed thereon, or after a developing process is performed thereon. At this time, the cover **123** is set at the upper position, and the wafer W is transferred onto the lifter pins **129** projecting upward from the heating plate **121**. Then, the lifter pins **129** are moved down, so that the wafer W is placed on the proximity pins **125** of the heating plate **121**, which is maintained at a predetermined temperature (Step **2**). Then, the cover **123** is moved down to close the heat processing space S.

Then, a heat process is performed in the first mode shown in FIG. **10**A (Step **3**), in which periphery exhaust is set in operation through the exhaust ports **138** while the purge gas is delivered as a shower from the gas delivery holes **133***a*, so that a heat process is performed while downflows are uniformly supplied onto the upper surface of the wafer W. In this step, since gas flows are formed as downflows uniformly supplied over the entire upper surface of the wafer W, the heat process can be realized uniformly over the entire surface of the wafer W, and thus the quality of a resist film or a coating film, such as a BARC, can be made uniform. Consequently, it is possible to improve the CD uniformity after development. In this step, the valve **154** and valve **146** are controlled in accordance with instructions transmitted from the controller **155**, so that the flow rate of the purge gas supplied from the purge gas supply mechanism **144** and the periphery exhaust rate from the exhaust ports **138** are controlled to form desired downflows.

Incidentally, when a wafer with a coating film formed thereon is heated, and particularly a heat process is performed immediately after the coating film is formed, a lot of gas and/or sublimed substances are generated. Conventionally, gas and/or sublimed substances of this kind do not cause a serious problem in quality. However, with a decrease in CD, e.g., to be 50 nm or less, these substances deposited on a wafer W may cause defects, thereby deteriorating the product yield. Particularly, where a baking process is performed on a wafer with a BARC for ArF formed thereon, a lot of gas and/or sublimed substances of this kind are generated and affect the process. In this respect, since the first mode comprises a step of supplying downflows onto the wafer W, arranged to give weight to uniformity, this mode is basically not suitable for removing gas and/or sublimed substances. If the first mode is modified to unreasonably increase the exhaust efficiency, the uniformity is impaired.

On the other hand, a center exhaust mode conventionally used is arranged to form gas flows along a wafer from the periphery of the wafer toward the center thereof, and to exhaust gas from the center of the ceiling wall. In this case, gas and/or sublimed substances are exhausted and removed along with the gas flows, so they are scarcely deposited on the wafer. This mode is poor in heat process uniformity, but the following matter has been found by studies made by the present inventors. Specifically, this mode, i.e., formation of such gas flows arranged to give weight to gas exhaust, does not impair the quality of a coating film, if this mode is used after the first mode is used for a heat process until the quality of the coating film is stabilized.

Accordingly, after the heat process is performed in the first mode, the heat process is performed in the second mode (Step **4**), in which gas is exhausted through the exhaust pipe **135** at the center of the ceiling wall **123***a* of the cover **123**. In this step, as shown in FIG. **10**B, since gas is exhausted through the exhaust pipe **135**, air is drawn from the air intake ports **136** through the air feed passages **137** into the heat processing space S, so that gas flows (exhaust gas flows) are formed along the wafer W from the periphery of the wafer W toward the center thereof. Consequently, gas and/or sublimed substances generated by the heat process are exhausted and removed through the exhaust passage, so they are scarcely deposited on the wafer W. Further, the gas flows thus formed can effectively remove gas and/or sublimed substances deposited on the wafer W due to the heat process being performed in the first mode. In this step, the following control is performed in accordance with instructions transmitted from the controller **155** after the heat process is performed in the first mode. Specifically, the valves **146** and **154** are closed to stop supply of the purge gas and periphery exhaust, or these valves are adjusted to form delivery flows from the gas delivery holes **133***a* which can hold off inflow of gas and/or sublimed substances generated from the coating film, while the valve **150** is opened to obtain a predetermined exhaust rate.

Consequently, desired gas flows are formed from the periphery toward the center. The heat process is completed when the second mode is finished.

Where the heat process is a baking process performed on a 300 mm-wafer coated with a BARC for ArF laser, the first mode and second mode in Steps **3** and **4** may employ the following conditions.

Baking temperature: 180 to 220° C. (such as 215° C.)

First Mode

Purge gas flow rate: 5 L/min

Periphery exhaust rate: 5 L/min

Second Mode

Center exhaust rate: 20 L/min

(Purge gas flow rate: 4 L/min (if necessary))

Switching timing from first mode to second mode (total 60 sec): 40 sec

After the heat process is performed on the wafer W for a predetermined time, the wafer is placed on the cooling plate **161** and subjected to a predetermined cooling process (Step **5**). The procedures for transferring the wafer at this time will be explained with reference to FIGS. **12**A to **12**C. At first, as shown in FIG. **12**A, the wafer W is moved up by the lifter pins **129**, and then the cooling plate **161** is moved to a position above the heating plate **121**. Then, as shown in FIG. **12**B, the lifter pins **129** is moved down to place the wafer W on the proximity pins **163** of the cooling plate **161**. Then, as shown in FIG. **12**C, the cooling plate **161** is moved to the original position and the cooling process is started. After this cooling process, the wafer W is unloaded through a transfer port (not shown) (Step **6**). According to this heat processing unit (CHP), since cooling can be performed immediately after heating, wafers do not differ in thermal history, so fluctuations of the heat process among the wafers can be smaller.

As described above, the processing unit according to this embodiment is arranged to be switchable between the first mode and second mode. Conventionally, there is no such an idea of switching gas flow formation modes in heat processing units. In the circumstances, the present inventors have found for the first time that switching such modes in the middle of a heat process allows both of high CD uniformity and high product yield to be realized.

Next, an explanation will be given of a heat processing unit according to an alternative embodiment of the present invention.

FIG. **13** is an enlarged sectional view showing a heating section used in a heat processing unit according to an alternative embodiment. FIG. **14** is a sectional plan view schematically showing the heating section. This embodiment has the same basic structure as that of the previous embodiment, except that a gas flow formation system of a heating section used for the second mode differs from that of the previous embodiment. Accordingly, in FIGS. **13** and **14**, the same constituent elements as those described above are denoted by the same reference numerals used in FIG. **7**, and their explanation will be omitted.

The heat processing unit according to this embodiment includes a casing, as in the previous embodiment, in which a heating section and a cooling section are located side by side. The heating section **120'** includes a heating plate **121** structured completely the same as that of the previous embodiment. The heating plate **121** is supported within the inner space of a support member **222** and the upper side of the support member **222** is covered with a cover **223**. The support member **222** has a compressed rectangular cylindrical shape opened upward, while the cover **223** has a compressed rectangular cylindrical shape opened downward. As in the cover **123** of the previous embodiment, the cover **223** can be moved up and down. When the cover **223** is set at the upper position, the wafer W can be loaded and unloaded to and from the heating plate **121**. When the cover **223** is set at the lower position, the cover **223** cooperates with the support member **222** to form a heat processing space S'.

The cover **223** is formed of a ceiling wall **223***a* and a sidewall **223***b*. The ceiling wall **223***a* includes an upper plate **232** and a lower plate **233**, which define a gas diffusion space d' therebetween. Further, the lower plate **233** of the ceiling wall **223***a* has a number of gas delivery holes **233***a* uniformly distributed.

The sidewall **223***b* of the cover **223** further has a plurality of gas exhaust ports **238** opened on the inner surface and arrayed along a lower side of the inner surface. A plurality of vertical exhaust passages **240** are formed in the sidewall **223***b* such that they extend horizontally from the gas exhaust ports **238** and then extend vertically upward. Further, a loop exhaust passage **241** is formed in an upper side of the sidewall **223***b*, and is connected to the vertical exhaust passages **240**.

Furthermore, the sidewall **223***b* of the cover **223** has a gas delivery port **242***a* formed in a wall portion on the cooling section side at a position immediately above the heating plate **121**. The gas delivery port **242***a* has a thin and long shape extending in a horizontal direction, and is connected to a plurality of vertical gas flow passages **243***a* vertically extending in this wall portion of the sidewall **223***b*. Further, a horizontal gas flow passage **244***a* extending in a horizontal direction is formed in an upper side of this wall portion, and is connected to the vertical gas flow passages **243***a*. On the other hand, the sidewall **223***b* of the cover **223** has an exhaust port **242***b* formed in a wall portion opposite to the wall portion described above at a position immediately above the heating plate **121**. The exhaust port **242***b* has a thin and long shape extending in a horizontal direction, and is connected to a plurality of vertical exhaust passages **243***b* vertically extending in this wall portion of the sidewall **223***b*. Further, a horizontal exhaust passage **244***b* extending in a horizontal direction is formed in an upper side of this wall portion, and is connected to the vertical exhaust passages **243***b*.

The ceiling wall **223***a* of the cover **223** has a purge gas feed port **245** opened on the upper surface, which is connected to a purge gas supply mechanism **247** through a purge gas line **246**. The purge gas feed port **245** is connected to a flow passage **248** formed in the upper plate **232**. A purge gas is supplied from the purge gas supply mechanism **247** through the flow passage **248** into a gas feed member **249** located at the center of an upper side of the gas diffusion space d', and is then supplied into the gas diffusion space d' in radial directions from the gas feed member **249**. The purge gas thus supplied into the gas diffusion space d' is then delivered from the gas delivery holes **233***a* of the lower plate **233** into the processing space S'. The purge gas line **246** is provided with a valve **250** for turning on/off the purge gas and adjusting the flow rate thereof.

On the other hand, the loop exhaust passage **241** is connected to exhaust passages **251** extending upward at a plurality of positions, which are connected to exhaust lines **252***a* above the cover **223**. The exhaust lines **252***a* are connected to a periphery exhaust mechanism **253** through a collecting exhaust line **252***b*. The collecting exhaust line **252***b* is provided with a valve **254** for turning on/off exhaust gas and adjusting the flow rate thereof. The interior of the heat processing space S' can be exhausted by the periphery exhaust mechanism **253** from the exhaust ports **238** through the vertical exhaust passages **240** and loop exhaust passage **241** and further through the exhaust lines **252***a* and collecting exhaust line **252***b*.

Further, the horizontal gas flow passage **244**_a_ is connected to a gas flow passage **255**_a_ extending upward, which is connected to a gas supply line **256**_a_ above the cover **223**. The gas supply line **256**_a_ is connected to a gas supply mechanism **257**_a_. The gas supply line **256**_a_ is provided with a valve **258**_a_ for turning on/off supply gas and adjusting the flow rate thereof. Further, the horizontal exhaust passage **244**_b_ is connected to an exhaust passage **255**_b_ extending upward, which is connected to an exhaust line **256**_b_ above the cover **223**. The exhaust line **256**_b_ is connected to an exhaust mechanism **257**_b_. The exhaust line **256**_b_ is provided with a valve **258**_b_ for turning on/off exhaust gas and adjusting the flow rate thereof. A predetermined amount of gas, such as air, is supplied from the gas supply mechanism **257**_a_ through the gas flow passage **255**_a_, horizontal gas flow passage **244**_a_, and vertical gas flow passages **243**_a_, and is delivered from the gas delivery port **242**_a_ into the heat processing space S'. On the other hand, the interior of the heat processing space S' is exhausted, in accordance with the gas delivery, by the exhaust mechanism **257**_b_ through the exhaust port **242**_b_, vertical exhaust passages **243**_b_, horizontal exhaust passage **244**_b_, exhaust passage **255**_b_, and exhaust line **256**_b_. Consequently, unidirectional flows are formed within the heat processing space S'.

A controller **259** is used for turning on/off and adjusting the valves **250**, **254**, **258**_a_, and **258**_b_. The controller **259** controls the valves **250**, **254**, **258**_a_, and **258**_b_ in accordance with instructions transmitted from the process controller **101** of the central control section **19** to switch modes between a first mode shown in FIG. **15**A and a second mode shown in FIG. **15**B. In the first mode, periphery exhaust is set in operation through the exhaust ports **238** while the purge gas is delivered from the gas delivery holes **233**_a_, so that a heat process is performed while downflows are uniformly supplied onto the upper surface of the wafer W. In the second mode, a heat process is performed, while unidirectional flows are formed from the gas delivery port **242**_a_ to the exhaust port **242**_b_. In this embodiment, the purge gas supply mechanism **247**, periphery exhaust mechanism **253**, gas delivery holes **233**_a_, exhaust ports **238**, and lines connecting these portions constitute a first gas flow forming mechanism for forming gas flows used in the first mode. On the other hand, the gas supply mechanism **257**_a_, exhaust mechanism **257**_b_, gas delivery port **242**_a_, exhaust port **242**_b_, and the corresponding flow passages and lines constitute a second gas flow forming mechanism for forming gas flows used in the second mode.

Also in this embodiment, as in the previous embodiment, a heat process is first performed in the first mode arranged to give weight to the uniformity in film quality. Then, the heat process is performed in the second mode arranged to give weight to removal of gas and/or sublimed substances generated by the heat process. According to this embodiment, when the heat process is performed in the second mode, unidirectional flows are formed from the gas delivery port **242**_a_ to the exhaust port **242**_b_. Consequently, gas and/or sublimed substances generated by the heat process are exhausted and removed along with the unidirectional flows, and thus they are scarcely deposited on the wafer W. Further, the unidirectional flows thus formed can effectively remove gas and/or sublimed substances deposited on the wafer W due to the heat process being performed in the first mode. In the previous embodiment, since the exhaust pipe **135** is located directly above the wafer W, dust derived from gas and/or sublimed substances retained or deposited in the exhaust pipe **135** may drop onto the wafer W. In this respect, according to this embodiment, there is no such a risk. Further, since there is no need to form an exhaust structure on the ceiling wall, the dimension of the heat processing unit in the vertical direction can be decreased.

The present invention is not limited to the embodiments described above, and it may be modified in various manners. For example, in the embodiments described above, a heat process is first performed in a mode arranged to uniformize the quality of a coating film, and then in a mode arranged to remove gas and/or sublimed substances generated from the coating film. However, there is a coating film that tends to generate gas and/or sublimed substances at an early stage. For such case, a heat process may be first performed in a mode arranged to remove gas and/or sublimed substances, and then in a mode arranged to uniformize the film quality. Further, depending on the target substrate, a heat process may be performed only in a mode arranged to uniformize the quality of a coating film, or only in a mode arranged to remove gas and/or sublimed substances generated from a coating film.

In the embodiments described above, the heat processing unit includes a cooling plate. However, as a matter of course, the present invention may be applied to a heat processing unit including no cooling plate.

The present invention may be applied not only to a heat process used in ordinary photolithography, but also to a heat process used in a liquid immersion light exposure process.

In the embodiments described above, the present invention is applied to a heat process performed on a semiconductor wafer with a coating film formed thereon, but this is not limiting. For example, the present invention may be applied to a heat process performed on another substrate, such as a substrate for liquid crystal display devices (LCD), or a heat process performed on a substrate with no coating film formed thereon.

What is claimed is:

1. A heat processing apparatus comprising:

a heating plate configured to support and heat a substrate;

a cover configured to surround a space above the heating plate;

a first gas flow forming mechanism configured to form first gas flows within the space above the heating plate, the first gas flows being downward flows of gas uniformly supplied onto an upper surface of the substrate supported by the heating plate;

a second gas flow forming mechanism configured to form second gas flows within the space above the heating plate, the second gas flows being sideward flows of gas along the upper surface of the substrate supported by the heating plate; and

a control mechanism configured to control an operation of the apparatus and including a computer and a computer readable non-transitory storage medium that stores a control program,

wherein the control program, when executed, causes the computer to control the apparatus to conduct a heat processing sequence, wherein said computer is configured to execute a heat process by using the heating plate to heat a target substrate supported by the heating plate, wherein the space above the heating plate is surrounded by the cover,

wherein the heat process is performed along with first and second modes of gas flows sequentially set in this order while heating the target substrate by the heating plate,

the first mode uses the downward flows formed by the first gas flow forming mechanism to uniformize the heat process over the target substrate, and

the second mode uses the sideward flows formed by the second gas flow forming mechanism while exhausting

gas from the space above the heating plate to exhaust and remove at least one of gas and sublimed substances generated from the target substrate.

2. The apparatus according to claim **1**, wherein the second mode uses the sideward flows such that gas is caused to flow from a periphery of the target substrate toward a center thereof and then to be exhausted upward from the center.

3. The apparatus according to claim **1**, wherein the second mode uses the sideward flows such that gas is caused to flow from one side of the target substrate toward an opposite side thereof and then to be exhausted from the opposite side.

4. The apparatus according to claim **2**, wherein the first mode uses the downward flows such that gas is caused to flow from above onto the target substrate and then to be exhausted toward a periphery of the target substrate.

5. The apparatus according to claim **3**, wherein the first mode uses the downward flows such that gas is caused to flow from above onto the target substrate and then to be exhausted toward a periphery of the target substrate.

6. The apparatus according to claim **1**, wherein the cover includes a number of gas delivery holes formed in a counter plate facing the heating plate and communicating with a gas diffusion space that pools a purge gas, periphery exhaust ports opened at positions around the heating plate, a center exhaust port opened at a center of the counter plate and connected to an exhaust pipe, and gas intake ports opened at positions around the heating plate, such that the first gas flow forming mechanism forms the downward flows by supplying the purge gas from the gas delivery holes toward the substrate supported by the heating plate while exhausting gas on the substrate from the periphery exhaust ports, and the second gas flow forming mechanism forms the sideward flows by introducing gas from the gas intake ports while exhausting gas on the substrate supported by the heating plate from the center exhaust port.

7. The apparatus according to claim **1**, wherein the cover includes a number of gas delivery holes formed in a counter plate facing the heating plate and communicating with a gas diffusion space that pools a purge gas, periphery exhaust ports opened at positions around the heating plate, a side delivery port opened at a position on one side around the heating plate, and a side exhaust port opened at a position on an opposite side around the heating plate, such that the first gas flow forming mechanism forms the downward flows by supplying the purge gas from the gas delivery holes toward the substrate supported by the heating plate while exhausting gas on the substrate from the periphery exhaust ports, and the second gas flow forming mechanism forms the sideward flows by supplying gas from the side delivery port toward the substrate supported by the heating plate while exhausting gas on the substrate from the side exhaust port.

8. The apparatus according to claim **1**, wherein the target substrate includes a target film formed thereon and including a resist film or an anti-reflective coating for a resist film, and the heat processing sequence performs the heat process on the target film.

9. A computer readable non-transitory storage medium that stores a control program for a heat processing apparatus, which includes

a heating plate configured to support and heat a substrate,

a cover configured to surround a space above the heating plate,

a first gas flow forming mechanism configured to form first gas flows within the space above the heating plate, the first gas flows being downward flows of gas uniformly supplied onto an upper surface of the substrate supported by the heating plate,

a second gas flow forming mechanism configured to form second gas flows within the space above the heating plate, the second gas flows being sideward flows of gas along the upper surface of the substrate supported by the heating plate, and

a control mechanism configured to control an operation of the apparatus and including a computer,

wherein the control program, when executed, causes the computer to control the apparatus to conduct a heat processing sequence, which comprises:

supporting a target substrate by the heating plate to heat the target substrate and surrounding the space above the heating plate by the cover; and

then performing a heat process on the target substrate by heating the target substrate by the heating plate,

wherein the heat process is performed along with first and second modes of gas flows sequentially set in this order while heating the target substrate by the heating plate,

the first mode uses the downward flows formed by the first gas flow forming mechanism to uniformize the heat process over the target substrate, and

the second mode uses the sideward flows formed by the second gas flow forming mechanism while exhausting gas from the space above the heating plate to exhaust and remove at least one of gas and sublimed substances generated from the target substrate.

10. The storage medium according to claim **9**, wherein the second mode uses the sideward flows such that gas is caused to flow from a periphery of the target substrate toward a center thereof and then to be exhausted upward from the center.

11. The storage medium according to claim **9**, wherein the second mode uses the sideward flows such that gas is caused to flow from one side of the target substrate toward an opposite side thereof and then to be exhausted from the opposite side.

12. The storage medium according to claim **10**, wherein the first mode uses the downward flows such that gas is caused to flow from above onto the target substrate and then to be exhausted toward a periphery of the target substrate.

13. The storage medium according to claim **11**, wherein the first mode uses the downward flows such that gas is caused to flow from above onto the target substrate and then to be exhausted toward a periphery of the target substrate.

14. The storage medium according to claim **9**, wherein the cover includes a number of gas delivery holes formed in a counter plate facing the heating plate and communicating with a gas diffusion space that pools a purge gas, periphery exhaust ports opened at positions around the heating plate, a center exhaust port opened at a center of the counter plate and connected to an exhaust pipe, and gas intake ports opened at positions around the heating plate, such that the first gas flow forming mechanism forms the downward flows by supplying the purge gas from the gas delivery holes toward the substrate supported by the heating plate while exhausting gas on the substrate from the periphery exhaust ports, and the second gas flow forming mechanism forms the sideward flows by introducing gas from the gas intake ports while exhausting gas on the substrate supported by the heating plate from the center exhaust port.

15. The storage medium according to claim **9**, wherein the cover includes a number of gas delivery holes formed in a counter plate facing the heating plate and communicating with a gas diffusion space that pools a purge gas; periphery exhaust ports opened at positions around the heating plate; a side delivery port opened at a position on one side around the heating plate, and a side exhaust port opened at a position on an opposite side around the heating plate, such that the first

gas flow forming mechanism forms the downward flows by supplying the purge gas from the gas delivery holes toward the substrate supported by the heating plate while exhausting gas on the substrate from the periphery exhaust ports, and the second gas flow forming mechanism forms the sideward flows by supplying gas from the side delivery port toward the substrate supported by the heating plate while exhausting gas on the substrate from the side exhaust port.

16. The storage medium according to claim **9**, wherein the target substrate includes a target film formed thereon and including a resist film or an anti-reflective coating for a resist film, and the heat processing sequence performs the heat process on the target film.

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